CHAPTER 2
POWER SYSTEM REQUIREMENTS

2-1. Characteristics. Electrical characteristics of the power system will be selected during the initial design phase to provide a safe and efficient distribution of power, and will be based upon the size and types of loads to be served. The neutral conductor of all distribution systems operating at phase-to-phase voltages of 600 volts or less will be solidly grounded, except where ungrounded-neutral systems are required by the NEC, or as other applicable criteria specifically authorize.

a. Voltage. Distribution and utilization voltages employed will be of the highest order practicable consistent with the load to be served. Generally, single-phase, three-wire, 120/240-volt or three-phase, four-wire, 208Y/120-volt systems will be used to serve small lighting and power loads. Large lighting and power loads will normally be served by three-phase, four-wire, 480Y/277-volt systems. Ventilated dry-type transformers will be used to reduce the voltage to meet 120-or 208-volt requirements. Electrostatically-shielded, ventilated dry-type transformers will be provided where required by criteria for specific project applications. Other voltages will be used as necessary to serve specific loads. Delta-connected systems with the mid-point of one phase grounded will not be used except as specifically authorized by the Using Agency on an individual project basis.

b. Frequency. Generally, 60 Hertz will be the frequency employed for distribution and utilization voltages. Other frequencies may be used to serve specific loads or subsystems where required by the Using Agency.

2-2. Normal source systems. Generally, normal source systems will consist of radial distribution configurations consisting of a single transformer for each building or group of buildings for loads of 500 kVA or less at 208 volts, or 2,000 kVa or less at 480 volts. An economic analysis will be provided for 208-volt systems larger than 500 kVA or serving motors larger than 25 horsepower. For facilities having loads in excess of the above, secondary-selective configurations, consisting of double-ended transformer installations with normally open, interlocked bus-ties, and either open or closed switchgear lineups, will be used. In such instances, each transformer of the double-ended system will be sized to serve approximately 60 percent to 80 percent of the total demand load served.

a. Loading shedding. Automatic load shedding provisions will be provided only where specifically authorized by HQDA(DAEN-ECE-E), WASH DC 20314, or as authorized by TM 5-838-2 for Army hospitals. For Air Force projects authorization will be provided by HQ USAF/LEEEU, WASH DC, 20332, or by AFM 88–50.

b. Transformers. Distribution-class transformers used for facility power supply will normally be located exterior to such facilities, either on poles or at grade, and will be of the mineral-oil-insulated, self-cooled type. Criteria for exterior transformer installations are given in TM 5–811–1/AFM 88–9, Chapter 1.

(1) Distribution-class transformers may be located within large buildings at centers of load to avoid long low-voltage feeders and to attain a more economical installation. Generally, high fire point liquid-insulated or nonflammable fluid-insulated transformers, will be utilized within buildings in accordance with the requirements of the NEC, where rated primary transformer voltage exceeds 600 volts. Ventilated- or sealed-dry-type distribution transformers or mineral-oil-insulated units will be provided indoors, in accordance with the NEC only where they prove to be more economical than high fire point liquid-insulated or nonflammable fluid-insulated units. An economic analysis will be provided in the design analysis, along with the rationale supporting the decision, which will address life cycle cost comparisons between high fire point liquid-insulated, nonflammable fluid-insulated, ventilated- and sealed-dry-type, and mineral-oil-insulated units, including all building features required to accommodate each type, such as a vault and drainage system where required. All transformers and equipment addressed in the analysis will be equal in every electrical respect, including but not limited to capacities, voltages, overload capability, and basic impulse-insulation level (BIL), to accommodate a realistic comparison.

(2) Transformers having a primary voltage of 600 volts or less for the supply of lower voltages will be of the ventilated-dry-type, normally for floor or wall mounting, and will not exceed 500 kVA capacity. Where floor or wall mounting is not practicable, such units may be installed above suspended ceilings provided that all necessary electrical and working clearances are maintained; adequate access is provided; and future removal is not hampered by piping, ductwork, or other obstacles.

(3) Transformers located within buildings where noise is of concern, such as hospitals and administrative facilities, will have a low noise-level rating commensurate with the application, and will be

provided with vibration isolators to minimize sound transmission to the building structural system.

(4) Transformers normally will not be operated in parallel, since the resulting excessive interrupting duty requirements placed upon protective devices will greatly and unnecessarily increase the installation cost for such an arrangement. In those few cases where parallel operation in unavoidable, the design analysis will provide detailed rationale supporting the proposed arrangement.

2-3. Alternate source systems. An alternate source system will normally consist of battery supplies for small loads such as fire alarm or emergency lighting systems, or may include one or more diesel-engine-driven power generating units with associated controls and auxiliaries designed to provide electrical power during an interruption of the normal power supply for large loads. Facilities permitted to employ alternate source systems are given in AR 420-43.

a. Criteria. Alternate source system criteria for confinement facilities are given in appendix B, in AFM 88-50 for Air Force hospitals, and in TM 51-838-2 for Army hospitals. Starting, operating, and testing features for alternate sources given in TM 5-838-2 and in AFM 88-50 may be applied to other facilities, except that provisions for generator parallel operation and automatic load shedding therein will not be authorized for other Army facilities except as approved by HQDA(DAEN-ECE-E), WASH DC 20314, For Air Force projects approval will be obtained from HQ USAF/LEEEU, WASH, DC 20332.

b. Loads. Loads to be served by an alternate source, except as provided for in appendix A of TM 5-838-2, and AFM 88-50, will consist of critical systems and equipment only. Such critical loads will normally include alarm and detection systems, essential communications, exit and emergency lighting, security and surveillance systems, lighting required to conduct essential operations, generator-location lighting, and selected receptacles. For specific facilities, communications equipment, essential refrigeration, and other mission-essential equipment will also be supplied, as required by the Using Agency.

c. Battery supplies. For various facilities, such as auditoriums, some barracks, and others as required by the NEC and NFPA No. 101, alternate source systems may consist of integral- or central-system battery equipment. Where such equipment is appropriate, the decision to use either integral-system batteries (such as for exit lights) or central-system batteries (such as for combination loads consisting of extensive exit and emergency lighting systems and fire alarm and detection systems as well as for similar loads) will be left to the discretion of the designer, based upon economics, maintenance considerations and costs, and technical feasibility. Battery rooms (or rooms or areas in which batteries are charged) will be provided with ventilation sufficient to prevent the accumulation of over 2 percent gaseous hydrogen by volume. Battery rooms will not be located in hazardous areas and will not require hazardous location wiring or equipment. In general, approximately 0.016 cubic feet per hour of hydrogen gas is produced from each fully charged cell per charging ampere. Batteries and chargers of less than 50 volts do not require separate rooms or enclosures with access by qualified persons only (reference NEC 110-17). An exhaust fan will be provided to exhaust air at the required rate and vent directly to the outside. The fan will be supplied without switching by the battery charging circuit, or will be supplied separately but provided with an electrical or fail-safe mechanical interlock (such as a sail-switch), in order to prevent de-energization of the fan or fan circuit while the chargers are operating.

d. Non-MCA (Military Construction Authority) funded items. Equipment providing uninterruptible power system (UPS) support and/or other power conditioning between the power system and load may or may not be included under project construction contract authority depending upon the load. See AR 420-43 and AR 310-34 for construction project authority as a function of the load served. These systems include items such as static and rotary UPSs, motor-generator buffers, frequency convertors, and regulators.

2-4. Services. Service-entrance equipment will be located in readily accessible spaces to facilitate disconnection of power in case of emergency. The service-entrance location will be coordinated with the exterior distribution system to ensure that service and feeder circuit lengths are as short as practicable.

a. Low-voltage services. Low-voltage service conductors (600 volts and below) normally will be installed underground from transformers either on poles or at grade. Aerial low-voltage service will be provided for buildings having service ampacities of 200 amperes or less which are located in areas of installations where appearance is of no concern, such as industrial or warehousing areas. Ampacity of services will be adequate for the total demand load. When demands will not occur simultaneously on all feeders, a demand factor of 85-90 percent will be applied to the summation of the individual feeder demand loads. Where experience indicates that a lower demand factor may be applied satisfactorily for service conductor sizing, such a factor may be used.

b. Services exceeding 600 volts. Services exceeding 600 volts will be limited to large facilities requiring a multiplicity of load centers, facilities having motors of 150 horsepower or larger, or those facilities where low-voltage services are impracticable due to cost or technical feasibility. Services to structures will be installed underground. Incoming services tapped from aerial distribution circuits will be provided with surge arresters at the service entrance equipment.

c. Service equipment. For services exceeding 600 volts, metal-enclosed, manually operated, fusible load-interrupter switches or power circuit breakers will normally be used. For low-voltage services, molded-case or low-voltage power circuit breakers, or fusible disconnect switches will normally be used. However, low-voltage power circuit breakers will be selected only where the added cost incurred by their use can be justified by operational considerations. Generally, a single disconnecting means will be provided for each facility. Multiple disconnects will be avoided, except where major economies can be realized in large capacity services or where multiple service voltage requirements exist. Equipment ampacities will be adequate for the estimated demands, plus a reserve of approximately 10 to 20 percent for future growth. Larger reserves may be applied where a specifically documented need exists. Equipment will be capable of safely performing all interrupting functions based on the available system capacity and characteristics.

d. Meters. Energy usage and demand meters will not be provided for all facilities. Provisions for the installation of such meters will be made where authorized by HQDA(DAEN-ECE-E), WASH DC. For Air Force projects authorization will be obtained from HQ USAF/LEEEU, WASH DC.

e. Equipment rooms. Equipment room space required by major items of equipment such as switchgear, transformers, and generators will be determined at the earliest practicable phase of design. Closets for the installation of panelboards, equipment racks, and similar items will also be provided where appropriate. Equipment space requirements will be coordinated with mechanical system requirements and the structure design. Direct exterior access to major equipment areas will be provided whatever practicable to facilitate removal and maintenance. The design of equipment rooms and closets will be such that equipment can be removed and replaced without interference with other systems or equipment, and without requiring building modifications. Ventilation will be provided as required to permit equipment to operate within normal ambient temperature limitations; otherwise, the equipment will be derated accordingly.

2-5. Grounding. The neutral conductors of all systems operating at 600 volts or less, phase-to-phase, will be solidly grounded. Ungrounded neutral systems or circuits will be permitted only where specifically authorized by other criteria. Methods of grounding and installation will conform to the requirements of the NEC except as modified herein. Generally, grounding electrodes will consist of metallic rods not less than 3/4-inch diameter, 8 feet long, driven into the earth at the exterior of the building. The effectiveness of driven rods depends upon soil temperature, resistivity, and moisture content. Soil characteristic test borings will be helpful in determining the most effective electrode material and arrangement to be used where experience is lacking in such regard for a given project location. Copper-clad steel rods will normally be used. Where low soil resistivities are encountered and corrosion may occur due to electrolytic action between adjacent underground metallic masses and copper-clad rods, zinc-coated or stainless steel rods will be used. In areas where a deep water table exists, sectional-type rods may be used in series, driven to a depth to attain permanent moisture. Rods may be installed in multiples on a lateral spacing not less than their buried depth. Electrode resistance to ground should not exceed 25 ohms under normally dry conditions.

2-6. Lightning and static electricity protection. Criteria for lighting and static electricity protection will be provided in accordance with provisions of TM 5-811-3/AFM 88-9, Chapter 3. Grounding electrodes for such systems will be interconnected below grade with the power system electrodes.